Test Report

BD Medical
920 East 19th Street
Columbus, Nebraska 68601

EO Sterilization Chamber
EO DRE Test

Test Date: July 12, 2019

AST Project No. 2019-0436D

Prepared By
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Regulatory Information

Permit No.(s)
Regulatory Citation(s) 40 CFR Part 63, Subpart O

Source Information

Source Name
Sterilization Chamber – Catalytic Oxidizer

Target Parameter(s)
Ethylene Oxide - DRE

Contact Information

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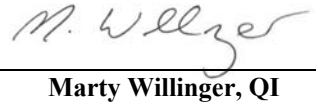
Alliance Source Testing, LLC (AST) has completed the source testing as described in this report. Results apply only to the source tested and operating conditions for the specific test date and time(s) identified within this report. All results are intended to be considered in their entirety, and AST is not responsible for use of less than the complete test report without written consent. This report shall not be reproduced in full or in part without written approval from the customer.

To the best of my knowledge and abilities, all information, facts and test data are correct. Data presented in this report have been checked for completeness and are accurate, error-free and legible. Onsite testing was conducted in accordance with approved procedures. Any deviations or problems are detailed in the relevant sections on the test report.

This report is only considered valid once an authorized representative of AST has signed in the space provided below; any other version is considered draft. This document was prepared in portable document format (.pdf) and contains pages as identified in the bottom footer of this document.



July 26, 2018

Marty Willinger, QI
Report Writer
Alliance Source Testing, LLC

Date

July 26, 2018

Kenneth Moody
Field Team Leader
Alliance Source Testing, LLC

Date

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Introduction

1.0 Introduction

Alliance Source Testing, LLC (AST) was retained by Becton-Dickinson Medical (BD Medical) to conduct compliance testing on the ethylene oxide (EO) sterilization chamber at the BD Medical facility located in Columbus, Nebraska. A performance test was conducted to quantify the concentrations and mass rates of EO into and out of the catalytic oxidizer to determine the EO destruction removal efficiency (DRE) on a mass basis. The performance test was conducted to satisfy testing requirements and demonstrate compliance with emission standards outlined in 40 CFR Part 63, Subpart O – Ethylene Oxide Emissions Standards for Sterilization Facilities. The catalytic oxidizer is required to demonstrate 99% DRE of EO.

1.1 Facility Description/ Source and Control System Descriptions

An EO sterilization chamber is in service at the BD Medical facility in Columbus, Nebraska. A catalytic oxidizer is used for control of EO emissions. The source identification and operating standards are provided in Table 1-1.

Table 1-1
Emission Limits

Source	Pollutant	Citation
Catalytic Oxidizer	Ethylene Oxide DRE ≥ 99% Catalyst bed outlet temperature to be recorded	40 CFR Part 63, Subpart O

1.2 Test Protocol & Notification

Testing was conducted in accordance with the test protocol submitted to NDEQ by BD Medical.

1.3 Test Program Notes

No test method deviations occurred during testing, expect as noted in the test protocol.

At the inlet sampling location, AST did not conduct EPA Method 4 sampling for measuring moisture content, due to possible EO exposure risks. Moisture content was measured from the outlet sampling location and used for both the inlet and outlet volumetric flow calculations and converting EO concentrations to a dry basis. EPA Method 4 sampling was completed from a single sample point at the outlet sampling location.

Summary of Results

2.0 Summary of Results

AST conducted compliance testing on the EO sterilization chamber on July 12, 2019.

Three (3), 1-hour test runs will be conducted to determine the concentrations of EO into and out of the sterilization chamber. Concurrent volumetric flow rate (VFR) measurements were conducted to calculate mass rates. Since the contents of the gas streams are is essentially air, a dry molecular weight of 29.0 was assumed for gas velocity calculations. EO DRE was determined by comparing the inlet and outlet EO levels on a mass basis.

To determine the inlet and outlet levels of EO, direct-interface EPA Method 18 on-site gas chromatographs equipped with flame ionization detectors (GCFID). The GCFID were calibrated with EO balanced nitrogen standards certified to 2% accuracy and dilutions of certified standards.

The involved processes were operating under normal conditions. Applicable operating and control equipment parameters were recorded throughout the test program by BD Medical personnel for inclusion in the test report, including;

- Catalyst bed outlet temperature

Table 2-1 provide a summary of the emission testing results with comparisons to the applicable limits. Any difference between the summary results listed in the following table and the detailed results contained in appendices are due to rounding for presentation.

Table 2-1
Summary of Results

Emissions Data					
Run Number	**1**	**2**	**3**	**Average**	**Emission**
Date	**07/12**	**07/12**	**07/12**	**--**	**Standard**
Operating Data					
Catalyst Bed Outlet Temperature, ºC	165	185	189	180	
Inlet Data					
H_2O Concentration, %vd	3.5	3.5	2.7	3.1	
VFR, dscfm	4,022	4,008	3,772	3,934	
EO Concentration, ppmvd	854.0	1105.7	1366.3	1108.7	
EO Rate, lb/hr	23.56	30.39	35.34	29.76	
Outlet Data					
H_2O Concentration, %vd	3.5	3.5	2.7	3.1	
VFR, dscfm	3,959	3,768	3,803	3,844	
EO Concentration, ppmvd	0.11	0.11	0.12	0.12	
EO Rate, lb/hr	0.0031	0.0029	0.0032	0.0031	
DRE Data					
EO DRE (lb/hr), %	99.99	99.99	99.99	99.99	≥ 99

Testing Methodology

3.0 Testing Methodology

Testing was conducted in accordance with U.S. Environmental Protection Agency (EPA) Reference Test Methods (RM) 1, 2, 4 and 18 referenced in 40 CFR Part 60, Appendix A. The emission testing program was conducted in accordance with the test methods listed in Table 3-1. Method descriptions are provided below while quality assurance/quality control (QA/QC) data are provided in Appendix C.

Table 3-1
Source Testing Methodology

Parameter	U.S. EPA Reference Test Methods	Notes
VFR	1-2	Full Velocity Traverses
O_2, CO_2	2	Assumed Ambient
H_2O	4	Gravimetric Analysis
EO	18	Gas Chromatograph

3.1 U.S. EPA Reference Test Methods 1 and 2 – Volumetric Flow Rate

The sampling location and number of traverse points were selected in accordance with EPA RM 1. To determine the minimum number of traverse points, the upstream and downstream distances were equated into equivalent diameters and compared to Figure 1-2 in EPA RM 1. All stack diameters, depths, widths, upstream and downstream disturbance distances and nipple lengths were measured on site with a verification measurement provided by the Field Team Leader.

Full velocity traverses were conducted in accordance with EPA RM 2 to determine the stack gas velocity pressure, static pressure and temperature. The velocity and static pressure measurement system consisted of a pitot tube and inclined manometer. The stack gas temperature was measured with a K-type thermocouple and pyrometer. The pitot assembly was leak checked pre and post each sampling period.

The temperature and differential pressure traverse data were combined with concurrently collected diluent data to calculate the stack gas velocity and volumetric flow rate in units of feet per second (ft/sec), actual cubic feet per minute (acfm), dry standard (1 atmosphere and 68°F) cubic feet per minute (dscfm) and pounds per hour (lb/hr). Since the contents of the gas streams are is essentially air, a dry molecular weight of 29.0 was assumed for gas velocity calculations.

3.2 U.S. EPA Reference Test Method 4 – Moisture Content

The stack gas moisture content was determined in accordance with EPA RM 4.

For each test run, a sample of gas for moisture determination was extracted from the stack at a constant flow rate of no more than 0.75 cubic feet per minute (cfm). The gas sample was passed through a stainless-steel probe, through a series of four (4) chilled glass impingers, and through a calibrated dry gas meter. In lieu of EPA RM 4 Section 8.1.1.1 requirements, a single sample point was used for moisture determination.

Prior to sampling, the first two impingers each were seeded with 100 milliliters of water. The third impinger was empty. The fourth impinger was seeded with 250 grams of dried silica gel. The sampling system was leak checked

pre and post each sampling period. Following sampling, the moisture gain in the impingers was measured gravimetrically and compared to the total sample volume (standard conditions) to determine the moisture content of the gas. The measured moisture content was compared to the saturation moisture content at stack temperature and pressure. The lower of the two moisture content values was reported.

3.3 U.S. EPA Reference Test Method 18 – Ethylene Oxide

Ethylene oxide concentrations were measured in accordance with EPA RM 18 using the direct interface sampling and analysis procedures detailed in the method. Samples were analyzed on-site with an HP Model 5890 Series II Gas Chromatograph equipped with dual RTX-1 columns to separate methane and EO, dual flame ionization detectors (FID) and Chemstation software.

Gas phase calibration standards were prepared by dilution of +/-2% accuracy certified gas standards. Preparation of diluted standards were conducted using a gas-tight volumetric syringe and new Tedlar bags. Triplicate injections were conducted for each standard, and a calibration curve of peak area versus concentration was prepared. A least squares line (y=mx) was fit to the inlet and outlet data set.

Following the GC calibrations, a recovery study (line loss) was conducted using certified EO gas standards with approximate concentrations of approximately 5,000 ppm and 50 ppm of EO for the inlet and outlet sampling systems, respectively. A successful recovery study was demonstrated with the mean, triplicate GC response within 10% of the certified gas concentration.

EO levels were measured at the inlet and outlet simultaneously. A gas sample was transported directly to the GC gas sampling valves using a heated sample line. Samples were analyzed approximately once every 10-minutes. A “test run” consisted of five (5) consecutive injections. Three (3), test runs were conducted (for a total of 15 injections) at the inlet and outlet of the catalytic oxidizer.

After completing the 3 test runs, the mid-level calibration standards were re-analyzed at the gas sampling valve in triplicate. The average of the initial calibration response (triplicate average) and the post-test check response (triplicate average) were within 5% of their mean value, and the initial calibration linear regression data were used to quantify EO levels.

The results of the GC analyses were used to calculate EO levels in units of ppmvw. The data were combined with stack gas VFR and H_2O data to calculate EO mass rates in units of pounds per hour (lb/hr) and concentrations in parts per million, dry volume basis (ppmvd). The catalytic oxidizer DRE was calculated on a mass basis.

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Gas phase calibration standards were prepared by dilution of +/-2% accuracy certified gas standards. Preparation of diluted standards were conducted using a gas-tight volumetric syringe and new Tedlar bags. Triplicate injections were conducted for each standard, and a calibration curve of peak area versus concentration was prepared. A least squares line (y=mx) was fit to the inlet and outlet data set.

Following the GC calibrations, a recovery study (line loss) was conducted using certified EO gas standards with approximate concentrations of 5000 ppm and 50 ppm of EO for the inlet and outlet sampling systems, respectively. A successful recovery study was demonstrated with the mean, triplicate GC response within 10% of the certified gas concentration.

Due to the presence of methane in the exhaust, prior to the test runs as well as during Run 2, a sample of exhaust gas was collected in a Tedlar bag. The contents of EO in the bag was quantified. Then the bag was spiked with a known concentration of EO to demonstrate adequate EO quantification and recovery. EO levels in the exhaust were below the reporting limit of 0.14 ppmvw.

EO levels were measured at the inlet and outlet simultaneously. A gas sample was transported directly to the GC gas sampling valves using a heated sample line. Samples were analyzed approximately once every 10-minutes. A “test run” consisted of five (5) consecutive injections. Three (3), test runs were conducted (for a total of 15 injections) at the inlet and outlet of the catalytic oxidizer.

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The results of the GC analyses were used to calculate EO levels in units of ppmvw. The data were combined with stack gas VFR and H_2O data to calculate EO mass rates in units of pounds per hour (lb/hr) and concentrations in parts per million, dry volume basis (ppmvd). The catalytic oxidizer DRE will be calculated on a mass basis.

Appendix A

Location	**Becton-Dickinson Medical**
Source	**Catalytic Oxidizer - Outlet**
Project No.	**2019-0436**
Run No.	**1**
Parameter(s)	**EO, VFR**

Meter Pressure (Pm), in. Hg

$$Pm = Pb + \frac{\Delta H}{13.6}$$

where,

Pb	28.65	= barometric pressure, in. Hg
ΔH	1.000	= pressure differential of orifice, in H_2O
Pm	28.72	= in. Hg

Absolute Stack Gas Pressure (Ps), in. Hg

$$Ps = Pb + \frac{Pg}{13.6}$$

where,

Pb	28.65	= barometric pressure, in. Hg
Pg	-0.21	= static pressure, in. H_2O
Ps	28.63	= in. Hg

Standard Meter Volume (Vmstd), dscf

$$Vmstd = \frac{17.647 \times Vm \times Pm}{Tm}$$

where,

Y	1.006	= meter correction factor
Vm	37.437	= meter volume, cf
Pm	28.72	= absolute meter pressure, in. Hg
Tm	545.9	= absolute meter temperature, ^oR
Vmstd	34.973	= dscf

Standard Wet Volume (Vwstd), scf

$$Vwstd = 0.04707 \times Vlc$$

where,

Vlc	26.8	= volume of H2O collected, ml
Vwstd	1.264	= scf

Moisture Fraction (BWSsat), dimensionless (theoretical at saturated conditions)

$$BWSsat = \frac{10^{6.37 - \left(\frac{2,827}{Ts + 365}\right)}}{Ps}$$

where,

Ts	139.3	= stack temperature, °F
Ps	28.6	= absolute stack gas pressure, in. Hg
BWSsat	0.2	= dimensionless

Moisture Fraction (BWS), dimensionless

$$BWS = \frac{Vwstd}{(Vwstd + Vmstd)}$$

where,

Vwstd	1.264	= standard wet volume, scf
Vmstd	34.973	= standard meter volume, dscf
BWS	0.035	= dimensionless

Molecular Weight (WET) (Ms), lb/lb-mole

$$Ms = Md\ (1 - BWS) + 18\ (BWS)$$

where,

Md	29.00	= molecular weight (DRY), lb/lb mol
BWS	0.035	= moisture fraction, dimensionless
Ms	28.62	= lb/lb mol

Location	**Becton-Dickinson Medical**
Source	**Catalytic Oxidizer - Outlet**
Project No.	**2019-0436**
Run No.	**1**
Parameter(s)	**EO, VFR**

Average Velocity (Vs), ft/sec

$$Vs = 85.49 \times Cp \times (\Delta P^{1/2})\,avg \times \sqrt{\frac{Ts}{Ps \times Ms}}$$

where,

Cp	0.81	= pitot tube coefficient
$\Delta P^{1/2}$	0.472	= average pre/post test velocity head of stack gas, $(in.\ H2O)^{1/2}$
Ts	599.3	= average pre/post test absolute stack temperature, °R
Ps	28.63	= absolute stack gas pressure, in. Hg
Ms	28.62	= molecular weight of stack gas, lb/lb mol
Vs	28.1	= ft/sec

Average Stack Gas Flow at Stack Conditions (Qa), acfm

$$Qa = 60 \times Vs \times As$$

where,

Vs	28.1	= stack gas velocity, ft/sec
As	3.01	= cross-sectional area of stack, ft^2
Qa	4,865	= acfm

Average Stack Gas Flow at Standard Conditions (Qs), dscfm

$$Qsd = 17.647 \times Qa \times (1 - BWS) \times \frac{Ps}{Ts}$$

where,

Qa	4,865	= average stack gas flow at stack conditions, acfm
BWS	0.035	= moisture fraction, dimensionless
Ps	28.63	= absolute stack gas pressure, in. Hg
Ts	599.3	= average pre/post test absolute stack temperature, °R
Qs	3,959	= dscfm

Dry Gas Meter Calibration Check (Yqa), dimensionless

$$Yqa = \frac{Y - \left(\frac{\Theta}{Vm} \sqrt{\frac{0.0319 \times Tm \times 29}{\Delta H @ \times \left(Pb + \frac{\Delta H\ avg.}{13.6} \right) \times Md}}\ \sqrt{\Delta H}\ avg. \right)}{Y} \times 100$$

where,

Y	1.006	= meter correction factor, dimensionless
Θ	60	= run time, min.
Vm	37.437	= total meter volume, dcf
Tm	545.9	= absolute meter temperature, °R
ΔH@	1.56	= orifice meter calibration coefficient, in. H_2O
Pb	28.65	= barometric pressure, in. Hg
ΔH avg	1.000	= average pressure differential of orifice, in H_2O
Md	29.00	= molecular weight (DRY), lb/lb mol
$(\Delta H)^{1/2}$	1.000	= average squareroot pressure differential of orifice, $(in.\ H_2O)^{1/2}$
Yqa	0.7	= dimensionless

Location: Becton-Dickinson Medical
Source: Catalytic Oxidizer - Outlet
Project No.: 2019-0436

Carbon Monoxide Emission Rate (ER_{CO}), lb/hr

$$ER_{EO} = \frac{C_{EO} \times MW \times Qs \times 60 \times 28.32}{24.04 \times 1.0E+06 \times 454}$$

where,

C_{EO}	0.1	= EO concentration, ppmvd
MW	44.05	= EO molecular weight, g/g-mole
Qs	3,959	= stack gas volumetric flow rate at standard conditions, dscfm
ER_{EO}	0.0031	= lb/hr

Carbon Monoxide Reduction Efficiency (RE_{CO}), %

$$RE_{EO} = \left(\frac{C_{EO-In} - C_{EO-Out}}{C_{EO-In}}\right) \times 100$$

where,

$C_{EO\text{-}Out}$	0.0031	= EO Inlet Concentration (corrected), lb/hr
$C_{EO\text{-}In}$	23.56	= EO Outlet Concentration (corrected), lb/hr
RE	99.99	= %

Appendix B

Location Becton-Dickinson Medical
Source Catalytic Oxidizer
Project No. 2019-0436
Parameter(s): EO, VFR

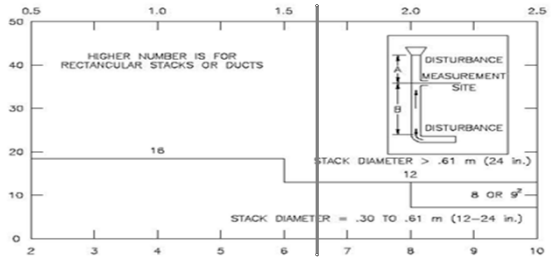
Run Number		Run 1	Run 2	Run 3	Average
Date		7/12/19	7/12/19	7/12/19	--
Start Time		9.:10	10:38	12:10	--
Stop Time		10:10	11:38	13:10	--
Inlet Data					
Volumetric Flow Rate, dscfm	(Qs)	4,022	4,008	3,772	3,934
Moisture Fraction	(BWS)	0.035	0.035	0.027	0.031
O2 Concentration, % dry	(O_2)	20.9	20.9	20.9	20.9
CO2 Concentration, % dry	(CO_2)	0.0	0.0	0.0	0.0
Ethylene Oxide Concentration, ppmvw	$C_{(EO)}$	824.22	1067.13	1329.86	1073.74
Ethylene Oxide Concentration, ppmvd	$C_{(EO)}$	854.00	1105.69	1366.33	1108.67
Ethylene Oxide Emission Rate, lb/hr	$ER_{(EO)}$	23.56	30.39	35.34	29.76
Outlet Data					
Volumetric Flow Rate, dscfm	(Qs)	3,959	3,768	3,803	3,844
Moisture Fraction	(BWS)	0.035	0.035	0.027	0.016
O2 Concentration, % dry	(O_2)	20.9	20.9	20.9	20.9
CO2 Concentration, % dry	(CO_2)	0.0	0.0	0.0	0.0
Ethylene Oxide Concentration, ppmvw	$C_{(EO)}$	0.11	0.11	0.12	0.11
Ethylene Oxide Concentration, ppmvd	$C_{(EO)}$	0.11	0.11	0.12	0.12
Ethylene Oxide Emission Rate, lb/hr	$ER_{(EO)}$	0.0031	0.0029	0.0032	0.0031
DRE Calculations					
Ethylene Oxide Reduction Efficiency, %	ER(EO)	99.99	99.99	99.99	99.99

Method 1 Data

Location Becton-Dickinson Medical
Source Catalytic Oxidizer - Inlet
Project No. 2019-0436
Date: 07/12/19

Stack Parameters

Duct Orientation:	Horizontal	
Duct Design:	Circular	
Distance from Far Wall to Outside of Port:	27.50	in
Nipple Length:	4.50	in
Depth of Duct:	23.00	in
Cross Sectional Area of Duct:	2.89	ft^2
No. of Test Ports:	2	
Distance A:	5.4	ft
Distance A Duct Diameters:	2.8	**(must be > 0.5)**
Distance B:	12.5	ft
Distance B Duct Diameters:	6.5	**(must be > 2)**
Minimum Number of Traverse Points:	12	
Actual Number of Traverse Points:	16	



CIRCULAR DUCT

LOCATION OF TRAVERSE POINTS

Number of traverse points on a diameter

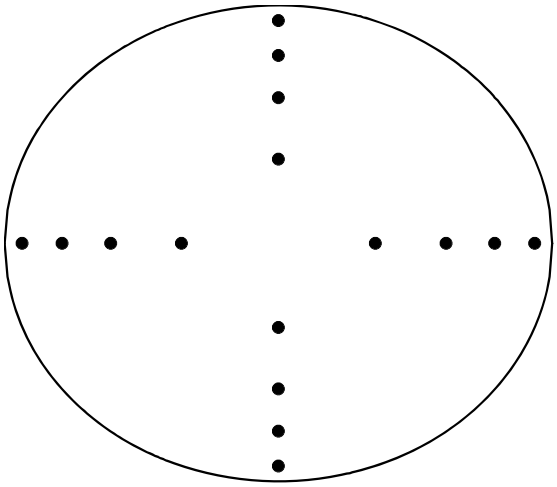
	2	3	4	5	6	7	8	9	10	11	12
1	14.6	--	6.7	--	4.4	--	3.2	--	2.6	--	2.1
2	85.4	--	25.0	--	14.6	--	10.5	--	8.2	--	6.7
3	--	--	75.0	--	29.6	--	19.4	--	14.6	--	11.8
4	--	--	93.3	--	70.4	--	32.3	--	22.6	--	17.7
5	--	--	--	--	85.4	--	67.7	--	34.2	--	25.0
6	--	--	--	--	95.6	--	80.6	--	65.8	--	35.6
7	--	--	--	--	--	--	89.5	--	77.4	--	64.4
8	--	--	--	--	--	--	96.8	--	85.4	--	75.0
9	--	--	--	--	--	--	--	--	91.8	--	82.3
10	--	--	--	--	--	--	--	--	97.4	--	88.2
11	--	--	--	--	--	--	--	--	--	--	93.3
12	--	--	--	--	--	--	--	--	--	--	97.9

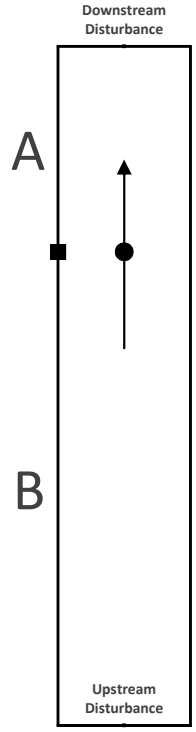
**Percent of stack diameter from inside wall to traverse point.*

Traverse Point	% of Diameter	Distance from inside wall	Distance from outside of port
1	3.2	0.74	5.24
2	10.5	2.42	6.92
3	19.4	4.46	8.96
4	32.3	7.43	11.93
5	67.7	15.57	20.07
6	80.6	18.54	23.04
7	89.5	20.59	25.09
8	96.8	22.26	26.76
9	--	--	--
10	--	--	--
11	--	--	--
12	--	--	--

Stack Diagram
A = 5.42 ft.
B = 12.5 ft.
Depth of Duct = 23 in.

Cross Sectional Area





Cyclonic Flow Check

Location Becton-Dickinson Medical
Source Catalytic Oxidizer - Inlet
Project No. 2019-0436
Date 7/12/19

Sample Point	Angle (ΔP=0)
1	3
2	2
3	3
4	3
5	2
6	1
7	5
8	4
9	6
10	3
11	2
12	2
13	7
14	1
15	2
16	5
Average	3.2

Location Becton-Dickinson Medical
Source Catalytic Oxidizer - Inlet
Project No. 2019-0436

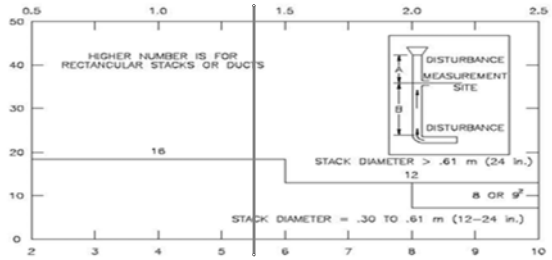
	Run No.	1		2		3	
	Date	7/12/19		7/12/19		7/12/19	
	Status	VALID		VALID		VALID	
	Start Time	9:35		11:08		12:35	
	Stop Time	9:42		11:15		12:40	
	Leak Check	Pass		Pass		Pass	
Traverse Point		**Δ P (in. WC)**	**Ts (°F)**	**Δ P (in. WC)**	**Ts (°F)**	**Δ P (in. WC)**	**Ts (°F)**
A1		0.17	90	0.23	91	0.21	97
2		0.21	88	0.22	90	0.19	97
3		0.23	88	0.21	89	0.18	92
4		0.23	87	0.20	89	0.17	92
5		0.22	87	0.22	88	0.19	91
6		0.21	86	0.21	88	0.19	91
7		0.22	85	0.20	88	0.20	92
8		0.23	85	0.21	89	0.21	91
B1		0.20	88	0.23	88	0.20	92
2		0.23	88	0.22	88	0.19	92
3		0.23	90	0.22	89	0.17	88
4		0.26	91	0.19	89	0.20	90
5		0.22	89	0.20	88	0.17	90
6		0.23	89	0.23	91	0.17	92
7		0.19	88	0.20	88	0.18	91
8		0.16	87	0.18	91	0.18	91
							Average
Square Root of ΔP, (in. WC)$^{1/2}$	**$(\Delta P)^{1/2}$**	0.463		0.459		0.433	0.451
Average ΔP, in. WC	**(ΔP)**	0.22		0.21		0.19	0.20
Pitot Tube Coefficient	**(Cp)**	0.814		0.814		0.814	0.814
Barometric Pressure, in. Hg	**(Pb)**	28.65		28.65		28.65	28.65
Static Pressure, in. WC	**(Pg)**	-7.20		-7.10		-7.10	-7.13
Stack Pressure, in. Hg	**(Ps)**	28.12		28.13		28.13	28.13
Average Temperature, °F	**(Ts)**	87.9		89.0		91.8	89.6
Average Temperature, °R	**(Ts)**	547.9		549.0		551.8	549.6
Measured Moisture Fraction	**(BWSmsd)**	--		--		--	--
Moisture Fraction @ Saturation	**(BWSsat)**	0.047		0.049		0.054	0.050
Moisture Fraction	**(BWS)**	0.035		0.027		0.027	0.030
O2 Concentration, %	**(O2)**	20.9		20.9		20.9	20.9
CO2 Concentration, %	**(CO2)**	0.0		0.0		0.0	0.0
Molecuar Weight, lb/lb-mole (dry)	**(Md)**	29.00		29.00		29.00	29.00
Molecuar Weight, lb/lb-mole (wet)	**(Ms)**	28.62		28.70		28.70	28.67
Velocity, ft/sec	**(Vs)**	26.6		26.3		24.9	25.9
VFR at stack conditions, acfm	**(Qa)**	4,601		4,556		4,310	4,489
VFR at standard conditions, scfh	**(Qsw)**	250,070		247,181		232,609	243,287
VFR at standard conditions, scfm	**(Qsw)**	4,168		4,120		3,877	4,055
VFR at standard conditions, dscfm	**(Qsd)**	4,022		4,008		3,772	3,934

Method 1 Data

Location Becton-Dickinson Medical
Source Catalytic Oxidizer - Outlet
Project No. 2019-0436
Date: 07/12/19

Stack Parameters

Duct Orientation:	Vertical	
Duct Design:	Circular	
Distance from Far Wall to Outside of Port:	27.50	in
Nipple Length:	4.00	in
Depth of Duct:	23.50	in
Cross Sectional Area of Duct:	3.01	ft^2
No. of Test Ports:	2	
Distance A:	40.0	ft
Distance A Duct Diameters:	20.4	**(must be > 0.5)**
Distance B:	10.8	ft
Distance B Duct Diameters:	5.5	**(must be > 2)**
Minimum Number of Traverse Points:	16	
Actual Number of Traverse Points:	16	



CIRCULAR DUCT

LOCATION OF TRAVERSE POINTS

Number of traverse points on a diameter

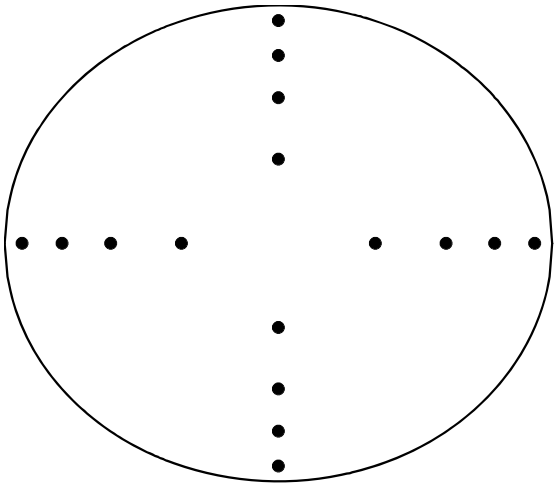
	2	3	4	5	6	7	8	9	10	11	12
1	14.6	--	6.7	--	4.4	--	3.2	--	2.6	--	2.1
2	85.4	--	25.0	--	14.6	--	10.5	--	8.2	--	6.7
3	--	--	75.0	--	29.6	--	19.4	--	14.6	--	11.8
4	--	--	93.3	--	70.4	--	32.3	--	22.6	--	17.7
5	--	--	--	--	85.4	--	67.7	--	34.2	--	25.0
6	--	--	--	--	95.6	--	80.6	--	65.8	--	35.6
7	--	--	--	--	--	--	89.5	--	77.4	--	64.4
8	--	--	--	--	--	--	96.8	--	85.4	--	75.0
9	--	--	--	--	--	--	--	--	91.8	--	82.3
10	--	--	--	--	--	--	--	--	97.4	--	88.2
11	--	--	--	--	--	--	--	--	--	--	93.3
12	--	--	--	--	--	--	--	--	--	--	97.9

**Percent of stack diameter from inside wall to traverse point.*

Traverse Point	% of Diameter	Distance from inside wall	Distance from outside of port
1	3.2	0.75	4.75
2	10.5	2.47	6.47
3	19.4	4.56	8.56
4	32.3	7.59	11.59
5	67.7	15.91	19.91
6	80.6	18.94	22.94
7	89.5	21.03	25.03
8	96.8	22.75	26.75
9	--	--	--
10	--	--	--
11	--	--	--
12	--	--	--

Stack Diagram
A = 40 ft.
B = 10.8 ft.
Depth of Duct = 23.5 in.

Cross Sectional Area



Cyclonic Flow Check

Location Becton-Dickinson Medical
Source Catalytic Oxidizer - Outlet
Project No. 2019-0436
Date 7/12/19

Sample Point	Angle (ΔP=0)
1	2
2	4
3	1
4	3
5	2
6	5
7	7
8	6
9	4
10	3
11	3
12	4
13	1
14	2
15	4
16	2
Average	3.3

Location Becton-Dickinson Medical
Source Catalytic Oxidizer - Outlet
Project No. 2019-0436

	Run No.	1		2		3	
	Date	7/12/19		7/12/19		7/12/19	
	Status	VALID		VALID		VALID	
	Start Time	9:21		10:55		12:48	
	Stop Time	9:28		11:05		12:56	
	Leak Check	Pass		Pass		Pass	
Traverse Point		**Δ P (in. WC)**	**Ts (°F)**	**Δ P (in. WC)**	**Ts (°F)**	**Δ P (in. WC)**	**Ts (°F)**
A1		0.15	147	0.15	136	0.14	128
2		0.18	144	0.16	135	0.18	129
3		0.22	128	0.20	136	0.20	127
4		0.22	126	0.20	141	0.20	123
5		0.21	134	0.21	141	0.21	121
6		0.22	147	0.23	135	0.19	122
7		0.23	152	0.21	138	0.22	122
8		0.23	152	0.22	130	0.21	122
B1		0.17	134	0.16	145	0.15	118
2		0.22	132	0.22	136	0.17	116
3		0.25	133	0.23	140	0.23	120
4		0.28	135	0.18	142	0.22	121
5		0.27	140	0.21	137	0.24	120
6		0.26	141	0.21	131	0.20	120
7		0.25	141	0.21	136	0.20	120
8		0.23	142	0.19	136	0.21	122
							Average
Square Root of ΔP, (in. WC)$^{1/2}$	**$(\Delta P)^{1/2}$**	0.472		0.446		0.444	0.454
Average ΔP, in. WC	**(ΔP)**	0.22		0.20		0.20	0.21
Pitot Tube Coefficient	**(Cp)**	0.814		0.814		0.814	0.814
Barometric Pressure, in. Hg	**(Pb)**	28.65		28.65		28.65	28.65
Static Pressure, in. WC	**(Pg)**	-0.21		-0.17		-0.18	-0.19
Stack Pressure, in. Hg	**(Ps)**	28.63		28.64		28.64	28.64
Average Temperature, °F	**(Ts)**	139.3		137.2		121.9	132.8
Average Temperature, °R	**(Ts)**	599.3		597.2		581.9	592.8
Measured Moisture Fraction	**(BWSmsd)**	--		--		--	--
Moisture Fraction @ Saturation	**(BWSsat)**	0.202		0.191		0.127	0.173
Moisture Fraction	**(BWS)**	0.035		0.027		0.027	0.030
O2 Concentration, %	**(O2)**	20.9		20.9		20.9	20.9
CO2 Concentration, %	**(CO2)**	0.0		0.0		0.0	0.0
Molecuar Weight, lb/lb-mole (dry)	**(Md)**	29.00		29.00		29.00	29.00
Molecuar Weight, lb/lb-mole (wet)	**(Ms)**	28.62		28.70		28.70	28.67
Velocity, ft/sec	**(Vs)**	28.1		26.4		26.0	26.8
VFR at stack conditions, acfm	**(Qa)**	4,865		4,577		4,501	4,648
VFR at standard conditions, scfh	**(Qsw)**	246,148		232,383		234,535	237,689
VFR at standard conditions, scfm	**(Qsw)**	4,102		3,873		3,909	3,961
VFR at standard conditions, dscfm	**(Qsd)**	3,959		3,768		3,803	3,844

Alliance SOURCE TESTING

Location Becton-Dickinson Medical
Source Catalytic Oxidizer - Outle
Project No. 2019-0436
Parameter(s): EO, VFR
Console Type Meter Box

Run No.		1					2					3				
Date		7/12/19					7/12/19					7/12/19				
Status		VALID					VALID					VALID				
Start Time		9.:10					10:38					12:10				
End Time		10:10					11:38					13:10				
Run Time, min	(θ)	60					60					60				
Meter ID		M5-25					M5-25					M5-25				
Meter Correction Factor	(Y)	1.006					1.006					1.006				
Orifice Calibration Value	(ΔH @)	1.560					1.560					1.560				
Max Vacuum, in. Hg		4					3					4				
Post Leak Check, ft3/min (at max vac.)		0.000					0.000					0.000				
Meter Volume, ft3																
0		113.879					151.512					190.261				
5		116.900					154.700					193.400				
10		120.000					157.900					196.600				
15		123.100					161.100					199.800				
20		126.200					164.200					203.100				
25		129.700					167.300					206.200				
30		132.400					170.500					209.400				
35		135.700					173.600					212.600				
40		139.000					176.800					215.900				
45		142.100					179.900					218.900				
50		145.300					183.100					222.100				
55		148.300					186.200					225.400				
60		151.316					189.379					228.670				
Total Meter Volume, ft3	(Vm)	37.437					37.867					38.409				
Temperature, °F		Meter	Probe	Filter	Vacuum	Imp. Exit	Meter	Probe	Filter	Vacuum	Imp. Exit	Meter	Probe	Filter	Vacuum	Imp. Exit
0		78	252	252	4	58	91	252	252	3	58	95	252	252	4	58
5		78	252	252	4	58	91	252	252	3	58	95	252	252	4	58
10		80	252	252	4	57	92	252	252	3	59	96	253	253	4	57
15		81	253	253	4	55	92	253	253	3	60	97	253	253	4	55
20		82	253	253	4	54	93	253	253	3	60	97	253	253	4	55
25		85	253	253	4	54	95	252	252	3	58	97	252	252	4	55
30		87	252	252	4	55	95	252	252	3	58	98	252	252	4	56
35		88	252	252	4	55	98	253	253	3	58	101	252	252	4	58
40		90	252	252	4	56	99	253	253	3	57	102	252	252	4	58
45		91	252	252	4	56	100	253	253	3	56	103	253	253	4	59
50		93	253	253	4	57	101	253	253	3	56	104	253	253	4	60
55		92	252	252	4	57	102	252	252	3	55	104	253	253	4	61
60		95	252	252	4	58	102	252	252	3	55	105	253	253	4	61
Average Temperature, °F	(Tm)	86	252	252	--	--	96	252	252	--	--	100	253	253	--	--
Average Temperature, °R	(Tm)	546	712	712	--	--	556	712	712	--	--	559	712	712	--	--
Minimum Temperature, °F		78	252	252	--	--	91	252	252	--	--	95	252	252	--	--
Maximum Temperature, °F		95	253	253	--	58	102	253	253	--	60	105	253	253	--	61
Barometeric Pressure, in. Hg	(Pb)	28.65					28.65					28.65				
Meter Orifice Pressure , in. WC	(ΔH)	1.000					1.000					1.000				
Meter Pressure, in. Hg	(Pm)	28.72					28.72					28.72				
Standard Meter Volume, ft3	(Vmstd)	34.973					34.733					35.022				
Analysis Type		Gravimetric					Gravimetric					Gravimetric				
Impinger 1, Pre/Post Test, mL		H2O		875.0	919.3	44.3	H2O		919.3	925.4	6.1	H2O		925.4	932.3	6.9
Impinger 2, Pre/Post Test, mL		H2O		853.8	825.1	-28.7	H2O		825.1	833.6	8.5	H2O		827.6	831.8	4.2
Impinger 3, Pre/Post Test, mL		Empty		638.8	642.1	3.3	Empty		640.6	642.1	1.5	Empty		641.1	643.6	2.5
Impinger 4, Pre/Post Test, g		Silica		907.9	915.8	7.9	Silica		915.8	919.9	4.1	Silica		919.9	927.0	7.1
Volume Water Collected, mL	(Vlc)	26.8					20.2					20.7				
Standard Water Volume, ft³	(Vwstd)	1.264					0.952					0.976				
Moisture Fraction Measured	(BWS)	0.035					0.027					0.027				
Static Pressure, in. WC	(Pg)	-0.21					-0.17					-0.18				
Stack Pressure, in. Hg	(Ps)	28.63					28.64					28.64				
Stack Temperature, °F	(Ts)	131					125					138				
Gas Molecular Weight, lb/lb-mole (dry)	(Md)	29.00					29.00					29.00				
DGM Calibration Check Value	(Yqa)	0.7					0.9					2.0				

Appendix C

Becton Dikinson Medical

Catalytic Oxidizer - Inlet / Outlet

7/12/2019

EPA Method 18: Determination of Gaseous Organic Compounds using Gas Chromatography

Initial Three-Point Calibration

(Inlet) High Level Calibration Standard

Cpd	Conc.	Inj. 1		Inj. 2		Inj. 3		Average		
ID	(ppm)	RT	AC	RT	AC	RT	AC	RT	AC	OK?
Ethylene Oxide	**5179.00**	3.906	9631715.0	3.912	9635232.0	3.912	9640443.0	3.910	9635797	Y

Mid-Level Calibration Standard

Cpd	Conc.	Inj. 1		Inj. 2		Inj. 3		Average		
ID	(ppm)	RT	AC	RT	AC	RT	AC	RT	AC	OK?
Ethylene Oxide	**2589.50**	3.890	4730595.5	3.895	4764450.5	3.898	4749841.0	3.894	4748296	Y

Low-Level Calibration Standard

Cpd	Conc.	Inj. 1	Sig.20015	Inj. 2	Sig.20016	Inj. 3	Sig.20017	Average		
ID	(ppm)	RT	AC	RT	AC	RT	AC	RT	AC	OK?
Ethylene Oxide	**1294.75**	3.900	2387160.0	3.902	2334272.3	3.909	2316294.3	3.904	2345909	Y

Initial Three-Point Calibration

(Outlet) Low Level Calibration Standard

Cpd	Conc.	Inj. 1		Inj. 2		Inj. 3		Average		
ID	(ppm)	RT	AC	RT	AC	RT	AC	RT	AC	OK?
Ethylene Oxide	**50.02**	4.222	172921.2	4.24	172524.5	4.24	172641.4	4.234	172696	Y

Mid-Level Calibration Standard

Cpd	Conc.	Inj. 1		Inj. 2		Inj. 3		Average		
ID	(ppm)	RT	AC	RT	AC	RT	AC	RT	AC	OK?
Ethylene Oxide	**25.01**	4.152	90423.1	4.172	91117.8	4.191	88411.7	4.172	89984	Y

Low-Level Calibration Standard

Cpd	Conc.	Inj. 1		Inj. 2		Inj. 3		Average		
ID	(ppm)	RT	AC	RT	AC	RT	AC	RT	AC	OK?
Ethylene Oxide	**12.51**	4.200	48065.7	4.200	48189.4	4.212	47008.1	4.204	47754	Y

Becton Dikinson Medical

Catalytic Oxidizer - Inlet / Outlet

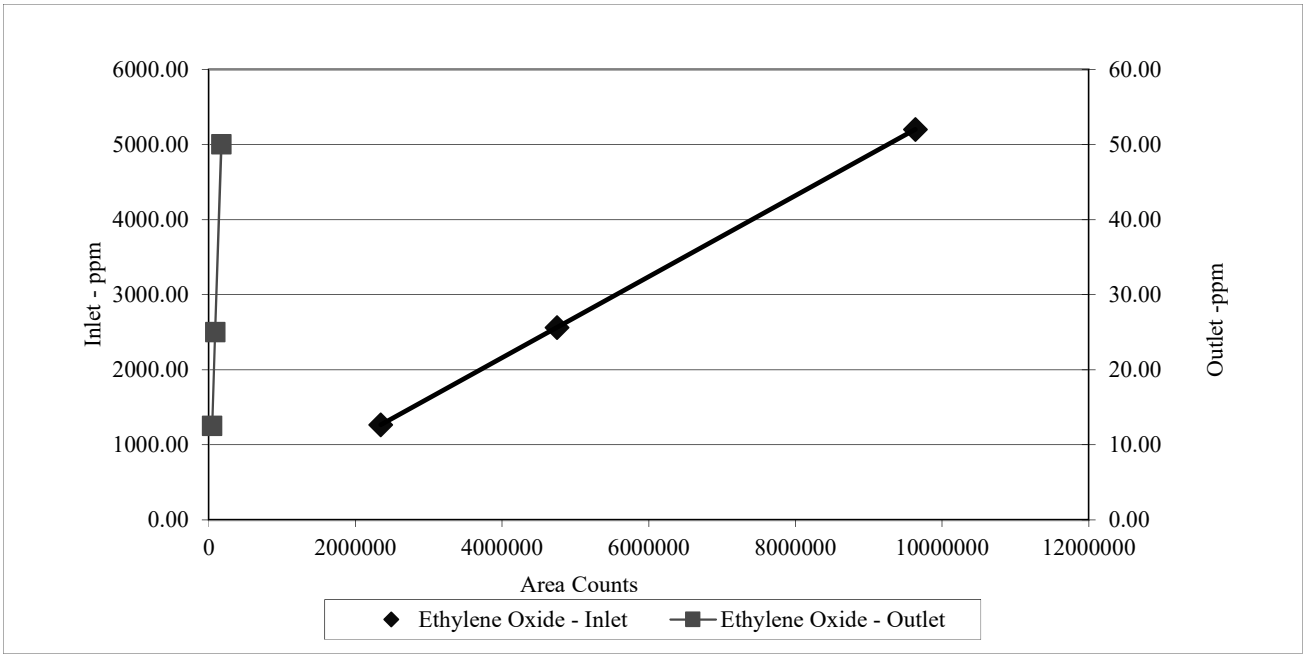
7/12/2019

EPA Method 18: Determination of Gaseous Organic Compounds using Gas Chromatography

Linear Regression Calculations

Ethylene Oxide - Inlet				
Certified ppm	Average AC	Linear Regression Statistics		ppm from curve
5179.00	9635797	R^2	M	5199.49
2589.50	4748296	1.0000	0.0005396	2562.19
1294.75	2345909			1265.86

Ethylene Oxide - Outlet				
Certified ppm	Average AC	Linear Regression Statistics		ppm from curve
50.02	172696	R^2	M	49.34
25.01	89984	1.0000	0.0002857	25.71
12.51	47754			13.64



Becton Dikinson Medical

Catalytic Oxidizer - Inlet / Outlet

7/12/2019

EPA Method 18: Determination of Gaseous Organic Compounds using Gas Chromatography

Quality Assurance Inlet												
Inlet Line Loss Check (High-level calibration gas to the sample probe)												
Cpd ID	Conc. (ppm)	Inj. 1 RT	Sig. 10059 AC	Inj. 2 RT	Sig. 10060 AC	Inj. 3 RT	Sig.10061 AC	Average RT	AC	ppm	Triplicate OK?	Recovery OK?
Ethylene Oxide	**5179.00**	3.912	9639243	3.912	9632581	3.914	9638738	3.913	9636854	5200.06	Y	Y

Inlet Post Test Calibration Check (mid-level calibration gas to the gas sampling valve)												
Cpd ID	Conc. (ppm)	Inj. 1 RT	AC	Inj. 2 RT	AC	Inj. 3 RT	AC	Average RT	AC	ppm	Triplicate OK?	Pre/Post OK?
Ethylene Oxide	**2589.50**	3.877	4717307.5	3.871	4693612.5	3.874	4671855.5	3.874	4694259	2533.03	Y	Y

BD Medical

Catalytic Oxidizer - Inlet / Outlet

7/12/2017

EPA Method 18: Determination of Gaseous Organic Compounds using Gas Chromatography

Quality Assurance Outlet												
Outlet Line Loss Check (High-level calibration gas to the sample probe)												
Cpd ID	Conc. (ppm)	Inj. 1 RT	Sig.20059 AC	Inj. 2 RT	Sig. 20060 AC	Inj. 3 RT	Sig.20061 AC	Average RT	AC	ppm	Triplicate OK?	Recovery OK?
Ethylene Oxide	**50.02**	4.238	169723.5	4.242	169468.1	4.25	172564	4.243	170585	48.74	Y	Y

Outlet Post Test Calibration Check (mid-level calibration gas to the gas sampling valve)												
Cpd ID	Conc. (ppm)	Inj. 1 RT	Sig.10043 AC	Inj. 2 RT	Sig.10044 AC	Inj. 3 RT	Sig.10045 AC	Average RT	AC	ppm	Triplicate OK?	Pre/Post OK?
Ethylene Oxide	**25.01**	4.005	96791.2	3.986	96755.6	3.99	96361.3	3.994	96636	27.61	Y	Y

Becton Dikinson Medical
Catalytic Oxidizer - Inlet / Outlet
7/12/2019
EPA Method 18: Determination of Gaseous Organic Compounds using Gas Chromatography

Sample Analysis (Inlet)

Run 1

Cpd	Inj. 1		Inj. 2		Inj. 3		Inj. 4		Inj. 5		Average		
ID	RT	AC	RT	AC	RT	AC	RT	AC	RT	AC	RT	AC	ppm
Ethylene Oxide	3.92	373377.1	3.917	1987208	3.922	2062162	3.92	2066465	3.926	1148072	3.921	1527457	**824.22**

Run 2

Cpd	Inj. 1		Inj. 2		Inj. 3		Inj. 4		Inj. 5				
ID	RT	AC	RT	AC	RT	AC	RT	AC	RT	AC	RT	AC	ppm
Ethylene Oxide	3.92	2033142.9	3.918	1739798	3.917	2018769	3.916	2010283	3.913	2086107	3.917	1977620	**1067.13**

Run 3

Cpd	Inj. 1		Inj. 2		Inj. 3		Inj. 4		Inj. 5		Average		
ID	RT	AC	RT	AC	RT	AC	RT	AC	RT	AC	RT	AC	ppm
Ethylene Oxide	3.908	2376301	3.905	1889175	3.903	2657426	3.903	2143161	3.901	3256551	3.904	2464523	**1329.86**

Sample Analysis (Outlet)

Run 1

Cpd	Inj. 1		Inj. 2		Inj. 3		Inj. 4		Inj. 5		Average		
ID	RT	AC	RT	AC	RT	AC	RT	AC	RT	AC	RT	AC	ppm
Ethylene Oxide	3.544	402.1	3.56	395.1	3.534	412.4	3.535	395.4	3.544	380.3	3.543	397	0.11

Run 2

Cpd	Inj. 1		Inj. 2		Inj. 3		Inj. 4		Inj. 5		Average		
ID	RT	AC	RT	AC	RT	AC	RT	AC	RT	AC	RT	AC	ppm
Ethylene Oxide	3.540	387.8	3.501	389.9	3.506	372.5	3.499	362.9	3.497	371.7	3.509	377	0.11

Run 3

Cpd	Inj. 1		Inj. 2		Inj. 3		Inj. 4		Inj. 5		Average		
ID	RT	AC	RT	AC	RT	AC	RT	AC	RT	AC	RT	AC	ppm
Ethylene Oxide	3.494	458.6	3.454	346	3.494	350.3	3.500	452.8	3.467	480.6	3.482	418	0.12

Wind Tunnel Pitot Calibration

S-type Pitot ID:	**P-674**	Date:	**13-Jan-11**
Standard Pitot ID:	**001**	Personnel:	**WB**
Cp(std):	**0.99**	Cp(actual):	**0.814**
Part Number:	**PPST12-Y-036**	P(bar):	**29.80**
Test Velocity (fps):	**50**	T(°F):	**33**

A-SIDE

ΔP_{std} (in. H_2O)	ΔP_s (in. H_2O)	Cp(s)	Deviation*
0.599	**0.898**	**0.809**	-0.003
0.601	**0.894**	**0.812**	-0.001
0.603	**0.889**	**0.815**	0.003
0.601	**0.891**	**0.813**	0.001
	AVERAGE	**0.812**	0.002
		Std deviation	0.003

B-SIDE

ΔP_{std} (in. H_2O)	ΔP_s (in. H_2O)	Cp(s)	Deviation*
0.595	**0.871**	**0.818**	0.002
0.597	**0.873**	**0.819**	0.002
0.593	**0.876**	**0.814**	-0.002
0.594	**0.879**	**0.814**	-0.002
	AVERAGE	**0.816**	0.002
		Std deviation	0.003

$$Cp(s) = Cp(std)\sqrt{\frac{\Delta P(std)}{\Delta P(s)}}$$

Cp(A) - Cp(B) = 0.004 {must be <0.010}

*Deviation = {Cp(s) - *AVG* Cp(s)} {must be <0.010}

Standard deviation of the deviations must be less than 0.02 for both sides.

Pitot tube S/N P-674 was calibrated in accordance with the CFR 40, Part 60 Appendix A, Method 2, Section 10.

Signature

1/13/2011
Date

AIR POLLUTION TESTING, INC.
DENVER, SALT LAKE CITY

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum volume of 10 cubic feet Vcr (STD). K' factors of~.8025 = 13 minutes, .5011 = 20 minu
4) Record data and information in the **GREEN** cells, YELLOW cells are calculated.

	INITIAL	FINAL	AVG (P_{bar})
BAROMETRIC PRESSURE (mbar):	833	834	833.5
BAROMETRIC PRESSURE (in Hg):	24.59849	24.6280	24.6133

DATE: 5/8/2019
METER PART #: NA
DGM SERIAL NUMBER: 18654624
CRITICAL ORIFICE MFG: Apex
METHOD 5 BOX ID: M5-25
TECHNICIAN/OPERATOR: Phil Brock

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	$\Delta H_@$
48	1	0.3433	19.5	223.0	233.252	10.252	72	77	74	77	75	75.75	23.0	0.44	8.3239	8.4283	1.013	1.48
	2	0.3433	19.5	245.002	255.271	10.269	71	74	75	75	77	75.25	23.0	0.44	8.3455	8.4363	1.011	1.48
	3	0.3433	19.5	255.271	265.515	10.244	71	75	73	77	74	74.75	23.0	0.44	8.3330	8.4363	1.012	1.48
																AVG =	1.012	
63	1	0.5849	17.0	265.515	276.159	10.644	71	76	78	75	78	76.75	14.0	1.35	8.6497	8.7490	1.011	1.58
	2	0.5849	17.0	276.159	286.875	10.716	71	78	76	78	77	77.25	14.0	1.35	8.7001	8.7490	1.006	1.58
	3	0.5849	17.0	286.875	297.556	10.681	71	76	74	77	75	75.5	14.0	1.35	8.70	8.7490	1.006	1.58
																AVG =	1.008	
73	1	0.8025	15.0	297.556	308.057	10.501	71	74	77	75	75	75.25	10.0	2.60	8.5892	8.5742	0.998	1.63
	2	0.8025	15.0	308.057	318.617	10.560	71	77	82	75	79	78.25	10.0	2.60	8.5893	8.5742	0.998	1.62
	3	0.8025	15.0	318.617	329.223	10.606	71	82	79	79	80	80	10.0	2.60	8.5987	8.5742	0.997	1.61
																AVG =	0.998	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m(std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = 1.006

AVERAGE $\Delta H_@$ = 1.56

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$
= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$
= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$
= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr(std)}}\right)^2 \Delta H \left(\frac{V_{m(std)}}{V_m}\right)$$

Pyrometer Calibration Data

Calibration Temp. Reading (F)	Pyrometer Reading (F)	ABS (Relative Difference) % R
0	2	0.4
50	50	0.0
100	99	0.2
150	150	0.0
250	252	0.3
500	499	0.1
800	802	0.2
Max Absolute Difference %.....		0.4

Omega Temp Calibrator ID 1
Omega Temp Calibrator S/N. T-197197
Calibration Date.....7/27/2017
Recert Date.....7/27/2018

Airgas
an Air Liquide company

CERTIFICATE OF ANALYSIS

Grade of Product: CERTIFIED STANDARD-SPEC

Airgas USA, LLC
616 Miller Cut Off Rd.
LaPorte, TX 77571
281-842-6900
Airgas.com

Customer:	ALLIANCE SOURCE TESTING		
Part Number:	X02NI99C15A5263	Reference Number:	126-401527371-1
Cylinder Number:	ALM-014712	Cylinder Volume:	144.4 CF
Laboratory:	124 - La Porte Mix - TX	Cylinder Pressure:	2015 PSIG
Analysis Date:	Jul 01, 2019	Valve Outlet:	350SS
Lot Number:	126-401527371-1		

Expiration Date: Jul 01, 2021

Product composition verified by direct comparison to calibration standards traceable to N.I.S.T. weights and/or N.I.S.T. Gas Mixture reference materials.

ANALYTICAL RESULTS

Component	Req Conc	Actual Concentration (Mole %)	Analytical Uncertainty
ETHYLENE OXIDE	50.00 PPM	50.02 PPM	+/- 2%
NITROGEN	Balance		

Notes:
RECERTIFICATION
ALLIANCE SOURCE TESTING

Approved for Release

Airgas
an Air Liquide company

Airgas USA, LLC
616 Miller Cut Off Rd.
LaPorte, TX 77571
281-842-6900
Airgas.com

CERTIFICATE OF ANALYSIS

Grade of Product: CERTIFIED STANDARD-SPEC

Customer:	ALLIANCE SOURCE TESTING		
Part Number:	X02NI99C15A0631	Reference Number:	126-401542179-1
Cylinder Number:	ALM013685	Cylinder Volume:	144.9 CF
Laboratory:	124 - La Porte Mix - TX	Cylinder Pressure:	2015 PSIG
Analysis Date:	Jul 03, 2019	Valve Outlet:	350
Lot Number:	126-401542179-1		

Expiration Date: Jul 03, 2020

Product composition verified by direct comparison to calibration standards traceable to N.I.S.T. weights and/or N.I.S.T. Gas Mixture reference materials.

ANALYTICAL RESULTS

Component	Req Conc	Actual Concentration (Mole %)	Analytical Uncertainty
ETHYLENE OXIDE	5210 PPM	5179 PPM	+/- 2%
NITROGEN	Balance		

Notes:

RECERTIFICATION
ALLIANCE SOURCE TESTING

Approved for Release

Appendix D

Lesni Stack Test Data

Date: 12 JUL 19 Recorded By: Delia Meyer

Time	% LEL 30.630	% LEL 30.633	Inlet Bed Temp °C (Control) 25.610	Outlet Bed Temp °C 25.611
13:00	5.1	4.7	161	195
13:10	5.1	4.5	160	196
13.20	5.2	5.0	160	196
13:30	5.4	5.1	162	200
13:40	3.8	3.5	161	194
13.50	4.1	4.6	162	202
14.00	3.2	3.0	165	201
14:10	4.7	4.4	163	199
14:20	5.6	5.2	164	203
14:30	3.1	2.8	164	199
14:40	4.2	3.9	164	202
14:50	3.1	2.8	166	203
15:00	5.0	4.7	164	201

Lesni Stack Test Data

Date: 12 JUL 19 **Recorded By:** Darin Meyer

Time	% LEL 30.630	% LEL 30.633	Inlet Bed Temp °C (Control) 25.610	Outlet Bed Temp °C 25.611
8:50 AM	0.2	0.0	161	161
9:00 AM	0.3	0.0	161	161
9:10 AM	0.3	0.0	161	161
9:20 AM	0.9	0.5	159	161
9:30 AM	1.0	0.5	159	160
9:40 AM	3.0	2.7	160	161
9:50 AM	3.0	2.5	159	164
10:00 AM	3.5	3.1	161	170
10:10 AM	3.4	2.9	159	177
10:20 AM	3.4	3.0	160	182
10:30 AM	3.4	2.7	161	184
10:40 AM	3.2	3.0	161	185
10:50 AM	2.6	2.2	159	182
11:00 AM	3.1	2.3	161	184
11:10 AM	3.1	2.7	159	185
11:20 AM	3.1	2.8	160	185
11:30 AM	2.9	2.6	159	186
11:40	3.0	2.6	160	185
11:50	3.4	3.1	161	186
12:00	1.1	1.0	160	187
12:10	3.8	3.5	160	187
12:20	3.1	2.5	160	186
12:30	3.7	3.5	159	184
12:40	3.1	3.5	159	188
12:50	4.1	4.0	159	189

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